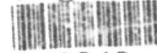


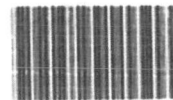
Region 8



9248

(2 OF 2)

CO00053



UIC 0697

204-079

205a(1) UIC - CO10787-00053 - PERMIT, TRI  
HOVENWEEP WELL # HWD-1

Fidr #: 9248

PRIV

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Quaternary deposits containing ground water have been identified in the reports referenced or included in the Administrative Record. However, these surficial deposits are normally less than 20 feet thick, except along valley bottoms, and no water wells utilize Quaternary deposits in the area, (Romero, 1985). "Dakota Sandstone, Burro Canyon, and Salt Wash Member strata are known aquifers in other areas and probably have water yielding properties in Section 16. The Junction Creek and Entrada Sandstones are known aquifers, and a well about 3 miles to the east in Section 13 probably taps one or both of these sandstones. Geologic units below the Entrada and above the Hermosa (Navajo, Windgate, Chinle) yield small quantities to water wells in other areas, but nothing is known of their yielding potential in the vicinity of the McElmo Dome Unit application", (Romero, 1985).

The Geological Setting data, formation names, lithology descriptions and depths, were obtained from EPA's 1987 Fact Sheet. The data for the base of the Ouray and depths of the Devonian (Elbert) and Undifferentiated Cambrian Formations were obtained from additional information submitted by the permittee. The total dissolved solids (TDS) values and zone types have been obtained from the permit application, additional data submitted by the permittee, and the reference document Ground Water Atlas of the United States, Segment 2.

**TABLE 2.1**  
**Geologic Setting**

<b>FORMATION NAME</b>	<b>GEOLOGICAL DESCRIPTION</b>	<b>TOP DEPTH, ft</b>	<b>BOTTOM DEPTH, ft</b>	<b>TDS mg/l</b>
Quaternary	Alluvial sands and gravels, loess, colluvium windblown sands	0	570	357 – 3790
Morrison	Light gray to pink sandstone and green or red mudstone	570	760	516
Bluff	Gray to buff Sandstone	760	1025	<10,000
Summerville	Red, sand mudstone, red sandstone and minor chert	1025	1143	<10,000
Entrada	Light buff, reddish brown or salmon colored fine grained sandstone	1143	1248	<10,000
Carmel	Reddish brown sandy siltstone and silty sandstone	1248	1265	<10,000
Navajo	Buff to pale orange cross bedded sandstone	1265	1398	2,760
Kayenta	Reddish sandstone and interbeds of red or green mudstone	1398	1440	<3,000
Wingate	Sandstone	1440	1950	<3,000
Chinle	Siltstone, sandstone, and mudstone	1950	2656	<10,000
Moenkopi	siltstone and sandstone	2656	2705	--



Cutler	Sandstones and Conglomerates	2705	4482	4,957-7,909; 38,000 – 78,000
Honaker Trail (Hermosa Group)	Sandstones, limestones, and shales	4482	5510	6730 – 381,436
Paradox	Interbedded salt, anhydrite, dark colored dolomites and black shale	5510	7970	No water
Pinkerton Trail	Light gray limestones and gray to gray green shales, siltstones and sandstones	7970	8116	No water
Molas	Interbedded red siltstones, sandstones, light colored limestones and varicolored shales	8116	8220	No water
Leadville - Ouray	Limestones and dolomite	8220	8630	78,727
Devonian (Elbert)	Shale, limestone, sandstone, and siltstone	8630	8980	15,200
Undifferentiated Cambrian	Siltstone, dolomite, and shale	8980	9400	182,246
Precambrian	Crystalline	9400	Basement	--

Note: "--" indicates no data available.

### Injection Zone

An injection zone is a geological formation, group of formations, or part of a formation that receives fluids through a well. The proposed injection zone(s) are listed in TABLE 2.2.

Injection will occur into an injection zone that is separated from USDWs by a confining zone which is free of known open faults or fractures within the Area of Review.

The Leadville/Ouray Formation water quality is quite variable. The TDS concentration ranges from 3000 milligrams per Liter (mg/l) to over 100,000 mg/l depending where the water sample is taken. The lower TDS values are drawn from above the gas-water interface, where the water is in vapor form and drops out as condensation, with the change in pressure and temperature when the gas is produced. The higher TDS concentrations come from below the gas-water interface where "free water" is occurring. The injection zone, in the permit application, was shown to have a TDS concentration of 35,350 mg/l. The injected fluid has a TDS concentration of 3,155 mg/l.

The Leadville Formation's hydrogeologic parameters include porosity, 8%; permeability, 2.7 millidarcy (md); pore pressure, 2,500 pounds per square inch (psi); fracture pressure, 4,330 psi; bottom-hole pressure, 3,220 psi (while injecting @ 3 barrels per minute); bottom-hole temperature, 180 F.

The gross permitted injection zone will be from the top of the Leadville at 8,220 feet to 8,630 feet in the Ouray. The Hovenweep has open perforations in the intervals of 8,480 – 8,534 feet. Perforations were squeezed at the completion of the well in the interval of 8,298 – 8,448 feet. The injection zone has been extended to the base of the

Cambrian Formation and top of the lower confining zone, Precambrian Formation. The Devonian Elbert and Cambrian Formations have been added as injection zones because there is no isolation between the four injection formations. Both the Devonian Elbert and Cambrian formations exists below the total depth of the well. Literature and available water quality data indicates that the formations may not be a USDW.

**TABLE 2.2**  
**INJECTION ZONE**

<b>Formation Name or Stratigraphic Unit</b>	<b>Top (ft)*</b>	<b>Base (ft)*</b>	<b>Porosity</b>	<b>Exemption Status</b>
Leadville - Ouray	8220	8630	3.5 - 25%	NA
Devonian Elbert	8630	8980	--	NA
Cambrian	8980	9400	--	NA

Notes: \* depths are approximate values at the wellbore.

--" indicates no data available.

### **Confining Zones**

A confining zone is a geological formation, part of a formation, or a group of formations that limits fluid movement above and below the injection zone. The confining zone or zones are listed in TABLE 2.3.

The Pennsylvanian "red bed" Molas Formation comprises the upper confining zone. This formation was evaluated by electric logs to estimate its petrophysical properties. These logs included a Borehole Compensated Sonic Log, a Compensated Neutron Log, a Formation Density Log, a Dual Lateral Log and microlaterolog-microlog. The interpretation of these logs showed the formation to be approximately 114 feet thick. The shales and siltstones of the Molas Formation have apparent log porosity but are impermeable. The limestone intervals are tight, with porosity less than 2 percent.

Other shale formations between the injection zone and the lowermost possible USDW include the Cutler Formation, the Moenkopi Formation and the Chinle Formation. These three units are considered redbeds and have low permeabilities. The Chinle Formation is 706 feet thick, the Moenkopi Formation is 49 feet thick and the Cutler Formation is 1777 feet thick. Calculations of TDS concentrations using resistivity logs have shown the Chinle and Cutler Formations not to be USDWs, although they are water bearing and produce water elsewhere in the region.

**TABLE 2.3**  
**CONFINING ZONES**

<b>Formation Name or Stratigraphic Unit</b>	<b>Top (ft)*</b>	<b>Base (ft)*</b>	<b>Lithology</b>
Molas	8116	8220	Interbedded red siltstones, sandstones, light colored limestones and varicolored shales
Precambrian	9400	Basement	Shale, limestone, sandstone, and siltstone

Note: \* depths are approximate values at the wellbore.



### Underground Sources of Drinking Water (USDWs)

Aquifers or the portions thereof which 1) currently supply any public water system or 2) contains a sufficient quantity of ground water to supply a public water system and currently supplies drinking water for human consumption or contain fewer than 10,000 mg/l TDS, are considered to be USDWs.

In the vicinity of the HWD-1 injection well, the base of the lowermost USDW is not definitively known. The available information reviewed by the operator suggests that the base of the usable USDW is likely associated with the base of the Mesozoic Sandstone Aquifer which generally coincides with the base of the Upper Triassic Wingate Sandstone. Per personal communication by the Permittee with a representative of the Colorado Department of Natural Resources, potential aquifers in the McElmo Dome Area include: Surficial deposits, the Dakota and Burro Canyon Formations, Saltwash member of the Morrison Formation, the Junction Creek and Entrada Sandstone and possibly the Chinle Formation.

There are additional formations in the area that could also be considered USDWs but are unknown because of the lack of data near the HWD-1 well. Based upon information submitted in the application, the Hermosa Group (Honaker Trail Formation) contains a TDS concentration ranging from 6,730 to 381,436 mg/L, and an average 202,700 mg/l, based on 23 samples from wells. The Honaker Trail may potentially be the base of USDWs in the area, but no water quality data is available to confirm this analysis. The Cutler and Rico Formations have aquifer potential, but definitive data are lacking.

USDWs are protected by cement behind pipe (surface and/or long string casing) from the surface to a depth of 2873 feet. Cement behind pipe of the surface casing extends from the surface into the Cutler Formation to a depth of 2873 feet. Cement resumes in the longstring casing from a depth of 4875 ft to the depth of 8020 feet. Confining geology of the Molas, Paradox Salts (approximately 1700 feet thick), Pinkerton trail, and Honaker Trail Formations confine injectate to the injection zones and protect upper USDWs by preventing the movement of fluids (contaminants) into USDWs in the area.

**TABLE 2.4**  
**UNDERGROUND SOURCES OF DRINKING WATER (USDWs)**

<b>FORMATION NAME</b>	<b>GEOLOGICAL DESCRIPTION</b>	<b>TOP DEPTH, ft</b>	<b>BOTTOM DEPTH, ft</b>
Quaternary	Alluvial sands and gravels, loess, colluvium windblown sands	0	570
Morrison	Light gray to pink sandstone and green or red mudstone	570	760
Bluff	Gray to buff Sandstone	760	1025
Summerville	Red, sand mudstone, red sandstone and minor chert	1025	1143
Entrada	Light buff, reddish brown or salmon colored fine grained sandstone	1143	1248
Carmel	Reddish brown sandy siltstone and silty sandstone	1248	1265
Navajo	Buff to pale orange	1265	1398

	cross bedded sandstone		
Kayenta	Reddish sandstone and interbeds of red or green mudstone	1398	1440
Wingate	Sandstone	1440	1950
Chinle	Siltstone, sandstone, and mudstone	1950	2656
Moenkopi	Siltstone and sandstone	2656	2705
Cutler	Sandstone and conglomerates	2705	4482
Honaker Trail	Sandstone, limestone and shale	4482	5510

### **PART III. Well Construction (40 CFR § 146.12)**

The approved well construction plan, incorporated into the Permit as APPENDIX A, will be binding on the Permittee. Modification of the approved plan during construction is allowed under 40 CFR § 144.52(a)(1) provided written approval is obtained from the Director prior to actual modification.

#### **Casing and Cement**

The well construction plan was evaluated and determined to be in conformance with standard practices and guidelines that ensure well injection does not result in the movement of fluid containing any contaminant into USDWs. Well construction details for the injection well(s) are shown in TABLE 3.1.

To protect shallow USDWs when drilling the surface hole, the Permittee is limited to drilling with air or mud made with water containing no additives and no more than 3,000 mg/l TDS, unless waived by the Director.

Remedial cementing may be required if the casing cement is shown to be inadequate by cement bond log or other demonstration of external (Part II) mechanical integrity.

**TABLE 3.1  
WELL CONSTRUCTION REQUIREMENTS**

<b>Casing Type</b>	<b>Hole Size (in)</b>	<b>Casing Size (in)</b>	<b>Cased Interval (ft)</b>	<b>Cemented Interval (ft)</b>
Conductor	17.5	13.375	0-50	0-50
Surface	12.25	9.625	0-2,873	0-2,873
Production/Longstring	8.75	7	0-8,020	4,875-8,020
Liner	6.125	4.5	7,827-8,581	7,827-8,581
Tubing	N/A	2.875	0-8,167	N/A

#### **Well Siting**

By definition, Class I wells must inject beneath the lowermost formation containing, within one-quarter mile of the well bore, a USDW.



ATTACHMENTS TO COMPLETION REPORT HWD-1

I. Geologic Information

1. Lithology and Stratigraphy

A. Description of Rock Units Penetrated

Name:	Dakota
Age:	Cretaceous
Depth:	Outcrops at surface
Thickness:	570'
Lithology:	Light gray sandstone and carbonaceous shale
Name:	Morrison
Age:	Jurassic
Depth:	570'
Thickness:	190'
Lithology:	Light gray to pink sandstone and green or red mudstone
Name:	Bluff
Age:	Jurassic
Depth:	760'
Thickness:	265'
Lithology:	Gray to buff sandstone
Name:	Summerville
Age:	Jurassic
Depth:	1025'
Thickness:	118'
Lithology:	Red, sand mudstone, red sandstone and minor chert
Name:	Entrada
Age:	Jurassic
Depth:	1143'
Thickness:	105'
Lithology:	Light buff, reddish brown or salmon colored fine-grained sandstone
Name:	Carmel
Age:	Jurassic
Depth:	1248'
Thickness:	17'
Lithology:	Reddish brown sandy siltstone and silty sandstone

Name:	Navajo
Age:	Jurassic
Depth:	1265'
Thickness:	133'
Lithology:	Buff to pale orange cross-bedded sandstone
Name:	Kayenta
Age:	Triassic
Depth:	1398'
Thickness:	42'
Lithology:	Reddish sandstone and interbeds of red or green mudstone
Name:	Wingate
Age:	Triassic
Depth:	1440'
Thickness:	510'
Lithology:	Pale orange and brown, fine-grained sandstone
Name:	Chinle
Age:	Triassic
Depth:	1950'
Thickness:	706'
Lithology:	Reddish brown siltstone and sandstone, reddish brown to variegated bentonitic mudstone, and minor gray conglomeratic sandstone
Name:	Moenkopi
Age:	Triassic
Depth:	2656'
Thickness:	49'
Lithology:	Reddish brown laminated siltstone, sandy siltstone and minor very fine-grained sandstone
Name:	Cutler
Age:	Permian
Depth:	2705'
Thickness:	1777'
Lithology:	Interbedded red, orange and purple sandstones, siltstones and shales



Name:	Honaker Trail
Age:	Pennsylvanian
Depth:	4482'
Thickness:	1028'
Lithology:	Interbedded gray sandstones, limestones and shales with scattered amounts of gray and orange chert
Name:	Paradox
Age:	Pennsylvanian
Depth:	5510'
Thickness:	2460'
Lithology:	Interbedded salt, anhydrite, dark colored dolomites and black shale
Name:	Pinkerton Trail
Age:	Pennsylvanian
Depth:	7970'
Thickness:	146'
Lithology:	Light gray limestones and gray to gray-green shales, siltstones and sandstones
Name:	Molas
Age:	Pennsylvanian
Depth:	8116'
Thickness:	114'
Lithology:	Interbedded red siltstones, sandstones, light colored limestones and varicolored shales
Name:	Leadville
Age:	Mississippian
Depth:	8230'
Thickness:	284'
Lithology:	Limestone, often oolitic and fossiliferous changing to dolomite in the lower half
Name:	Ouray
Age:	Devonian
Depth:	8514'
Thickness:	NP
Lithology:	Limestones and dolomite with occasional streaks of gray-green waxy shale

## B. Description of Injection Unit

Name: Leadville-Ouray  
Depth: 8230': Leadville  
Depth: 8514': Ouray  
Thickness: 304'  
Fluid Pressure: 2500 psi  
Age: Mississippian  
Porosity: 8%  
Permeability: 2.7 md  
Bottom hole temperature: 180°F  
Lithology: Limestone and Dolomite  
Bottom hole pressure: 3200 psi @ 3 BPM  
Fracture pressure: 4330 psi



## PART I. AUTHORIZATION TO CONSTRUCT AND OPERATE

Under the authority of the Safe Drinking Water Act (SDWA) and Underground Injection Control (UIC) Program regulations of the U. S. Environmental Protection Agency (EPA) codified at Title 40 of the Code of Federal Regulations (40 CFR) parts 2, 124, 144, 146, and 147, and according to the terms of this permit (Permit),

Kinder Morgan CO<sub>2</sub> Company LLC  
17801 U.S. Hwy 491  
Cortez, Colorado 81321

hereinafter referred to as the "Permittee," is authorized to operate the following Class I well:

HWD-1 (Hovenweep 1)  
515' FEL & 300' FNL, Section 9, T38N, R18W  
Montezuma County, Colorado

This Permit is based on representations made by the applicant and on other information contained in the administrative record. Misrepresentation of information or failure to fully disclose all relevant information may be cause for termination, revocation and reissuance, or modification of this Permit and/or formal enforcement action. It is the Permittee's responsibility to read and understand all provisions of this Permit.

Where a state or tribe is not authorized to administer the UIC program under the SDWA, EPA regulates underground injection of fluids into wells so that injection does not endanger Underground Sources of Drinking Water (USDWs). EPA UIC permit conditions are based on authorities set forth at 40 CFR parts 144 and 146 and address potential impacts to USDWs. Under 40 CFR part 144, subpart D, certain conditions apply to all UIC permits and may be incorporated either expressly or by reference. Regulations specific to Colorado injection wells are found at 40 CFR § 147 Subpart G.

The Permittee is authorized to engage in underground injection in accordance with the conditions of this Permit. Any underground injection activity not authorized by this Permit or by rule is prohibited.

Compliance with the terms of this Permit does not constitute a defense to any enforcement action brought under the provisions of Section 1431 of the SDWA or any other law governing protection of public health or the environment, nor does it serve as a shield to the Permittee's independent obligation to comply with all UIC regulations. Nothing in this Permit relieves the Permittee of any duties under applicable regulations.

This Permit is issued for 10 (ten) years from the Effective Date, until it expires under the terms of the Permit, or unless modified, revoked and reissued, or terminated under 40 CFR §§ 124.5, 144.12, 144.39, 144.40 or 144.41.

Issue Date: 7/8/2021

Effective Date: 8/7/2021

7/8/2021

**X** Lisa Kahn

Lisa Kahn, Acting Chief\*  
Water Division, Safe Drinking Water Branch  
Signed by: LISA KAHN

\* Throughout this Permit the term "Director" refers to the Safe Drinking Water Branch Chief or the Water Enforcement Branch Chief.

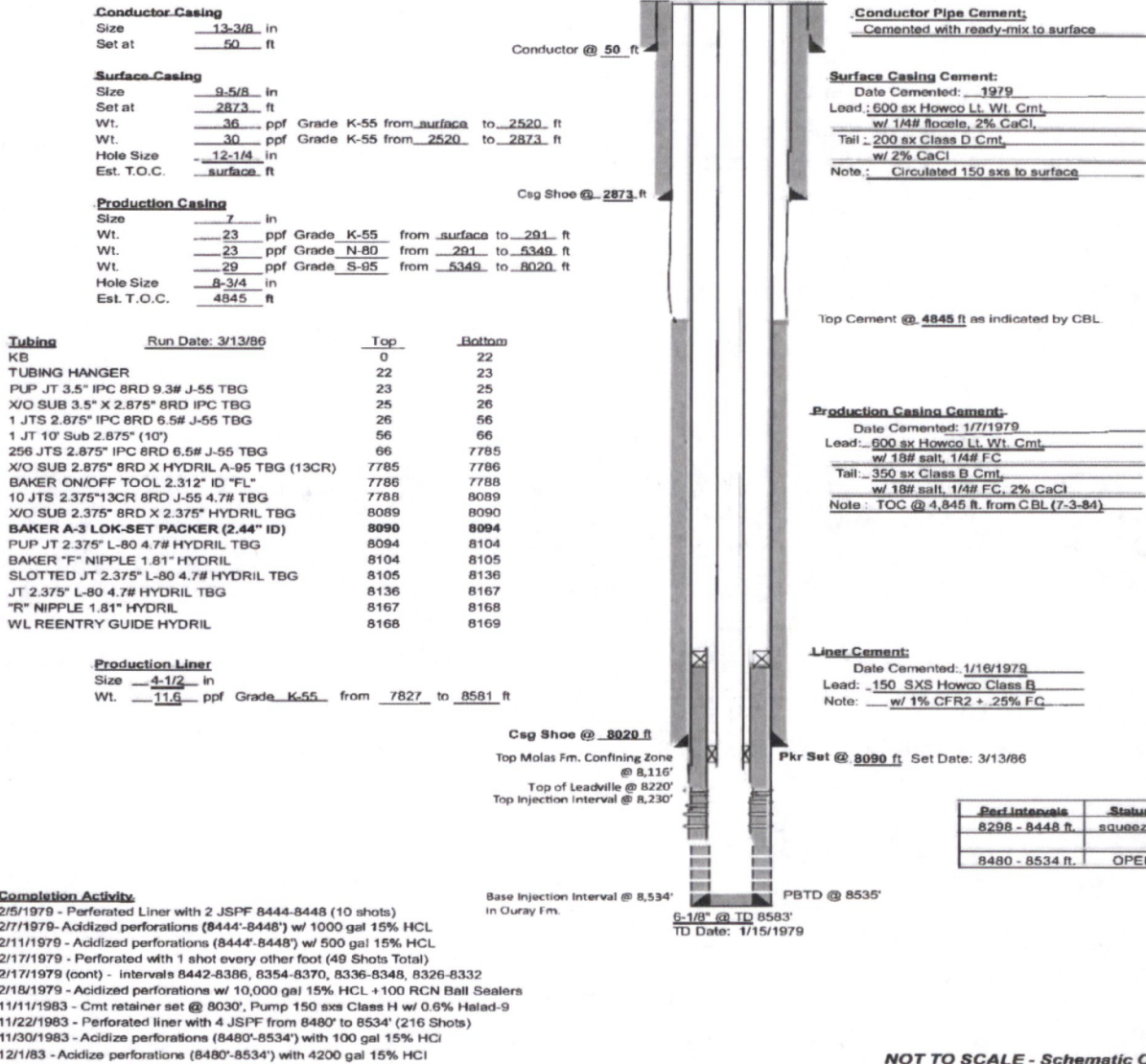
# INJECTION WELL CONSTRUCTION DIAGRAM

## Current Well Schematic for HWD-1

Well Name: Hovenweep Water Disposal 1 (HWD-1) Original Name: Yellow Jacket #2  
 Pilot API #: 05-083-06249-00  
 S/T API #: N/A  
 Section: 26 Township: 28N Range: 18W  
 Surface Hole: 300' FSL, 515' FEL Section 9, T38N R18W NMPM KB Elevation: 8,889 ft. (GL: 8,877 ft.)

Spud Date: 11/21/1978  
 Pilot Completion Date: 1/16/1979  
 S/T Completion Date: N/A

FILE: HWD-1 Schematic 2018 v2 - UJ dated 10/31/18 WEA





## APPENDIX C

### OPERATING REQUIREMENTS

#### INJECTION ZONE:

Injection is permitted only within the approved injection zone listed below. Injection perforations are limited to the Leadville and Ouray Formations; however, injection fluids may migrate into the Devonian Elbert and Cambrian Formations as long as the fluids remain within the approved injection zone described below. See Part II. Section B.2 and Part II. Section B.7 of this permit for more information.

#### APPROVED INJECTION ZONE (GL, ft.)

FORMATION NAME or STRATIGRAPHIC UNIT	TOP (ft.) *	BOTTOM (ft.) *
Leadville - Ouray	8220	8630
Devonian Elbert	8630	8980
Cambrian	8980	9400

\*estimated top and bottom depths of formations. These depths may be adjusted following the receipt of well interpretation data required in Appendix B.

#### MAXIMUM ALLOWABLE INJECTION PRESSURE:

The parameters below are the values used to calculate the initial authorized MAIP issued with this Permit. These parameters may be updated throughout the life of well, pursuant to the conditions and formula at Part II.B.4 of this Permit. Documentation to support a change must be provided and approved by the Director prior to recalculation of the MAIP.

#### MAIP Parameters

fracture gradient	specific gravity*	depth (ft.)	friction loss (PSI)	Calculated MAIP (PSI)	Authorized MAIP (PSI)
0.56	1.010	8220	NA	856	856

*\*From the MAIP equation in Part II, Section B.4(b), SG+0.05*

#### MAXIMUM INJECTION VOLUME:

There is no limitation on the fluid volume permitted to be injected into this well. In no case must injection pressure exceed the MAIP.

unsqueezed Leadville – Ouray perforations from 8480 to 8534 feet appear to be accepting 26% of the flow.

#### Protection of USDWs

- The injection zone lies between two (2) confining zones and above basement for the area as shown in Table 2.0 below (information obtained from Attachments D and F of the application). The formations which comprise the injection zone do not currently serve as sources of drinking water currently nor are they expected to be USDWs in the future because the total dissolved solids content (TDS values) are greater than 10,000 mg/L.

FORMATIONS	ZONES	LITHOLOGY	TOP, feet	BOTTOM, feet	TDS, mg/L
Molas	Confining	Interbedded red siltstones, sandstones, light colored limestones and varicolored shales	8116	8220	-
Leadville - Ouray	Injection	Limestones and dolomite	8220	8630	78,727
Devonian (Elbert)	Injection	Shale, limestone, sandstone, and siltstone	8630	8980	15,200
Undifferentiated Cambrian	Injection	Siltstone, dolomite, and shale	8980	9400	182,246
Precambrian	Confining	Crystalline	9400	Basement	--

*Table 2.0 – Formation Lithology Information*

- Water quality in the Devonian Elbert and Cambrian Formations is expected to be similar to the Leadville with a range from 20,000 to 200,000 mg/L based upon information in the Whitfield, et al. (1983) report. One Cambrian water sample analysis collected from a Utah well (located within T39, R23, Section 32) shows a TDS concentration of 182,246 mg/L. In Table D.1 of the application the HWD-2 well (located within T37N, R19W, Section 24) sample results for the Leadville, Ouray, Devonian and Cambrian Formations were 17,800 mg/L, 39,500 mg/L, 15,200 mg/L and 17,000 mg/L, respectfully.
- USDWs in the area extend from the surface to a depth of approximately 5,510 feet. As described in the Statement of Basis for the renewal permit, the lowermost USDW above the injection zone is the Honaker Trail Formation of the Hermosa Group occurring between 4,482 to 5,510 feet. These USDWs are isolated from the injection zone by approximately 2,710 feet of dolomites, shales and limestones. The HWD-1 well is constructed of casing with cement placed behind pipe to maintain fluids in the injection zone.
- Periodic testing of the well construction and monitoring of well operations protects USDWs by demonstrating that routine operations are not causing leaks or the upward movement of fluids.



4. **COMMENT #4:** Table 2.2 shows that no Porosity data is available for the Elbert and Cambrian formations. What projections have been made about potential available space in these additional formations? What volume of produced water will need to be disposed of over the next 10 years? This must be considered before any new well permits are approved.

**EPA RESPONSE #4:**

**Response 4A.** The porosity of the formations which comprise the injection zone are included in Table 3.0. See Attachments F and I of the application.

FORMATIONS	POROSITY, %
Leadville - Ouray	3.5 – 25, average 11.2
Devonian Elbert	11.2
Cambrian	11.2

*Table 3.0 – Porosity Data*

Attachment I – Formation Testing Program of the application identifies reservoir characteristics of the injection zones. Information was collected from Kinder Morgan wells: MWD-1, YWD-1, and HWD-1.

**Response 4B.** Currently, the Leadville and Ouray are the only formations that are perforated for injection. Therefore, the total volume of injected fluid is calculated only for the Leadville-Ouray formation. Once this volume has been reached the operator should contact EPA regarding performing any further injection. The calculated total volume of injected fluids allowed over the next ten years for the Leadville – Ouray is approximately 24,007,527 barrels. It was calculated with the use of the following formula.

$$V = (\pi r^2 h n) / 5.615 \text{ where:}$$

$$\pi = 3.14159265$$

$$r = 1,320 \text{ ft or } \frac{1}{4} \text{ mile} = \text{radial distance}$$

$$h = 335 \text{ ft} = \text{height of Leadville – Ouray injection zone available for fill up (ft)}$$

$$n = 11.2\% = \text{average porosity of injection zone (decimal percent)}$$

$$5.615 = \text{conversion factor (barrels and ft}^3\text{)}$$

$$Va = \text{barrels} = \text{maximum cumulative volume (bbl) total for the area of review from 1986 - 2031}$$

$$Vb = \text{Volume of fluid previously injected from 1986 to 2021 (1}^{st} \text{ quarter)} = \text{barrels}$$

$$Vtr = \text{remaining cumulative volume allowed for the area for 2021 (2}^{nd} \text{ Quarter)} - 2031 \text{ (4}^{th} \text{ Quarter)}$$

$$Va = (3.14159265 * 1320^2 * 410 * 0.08) / 5.615 = 36,577,229 \text{ barrels}$$

$$Vb = 12,569,702 \text{ barrels}$$

Approximate volume of total amount of fluid allowed for injection thru 2031 (4<sup>th</sup> quarter)

$$Vtr = 24,007,527 \text{ barrels}$$

Since the formations are not expected to be USDWs, the permit does not include a volume limit for the Leadville and Ouray Formations. If occurring, any fluid movement into the Devonian Elbert and/or the Cambrian formations is expected to be relatively low compared to the volume being injected directly into the Leadville and Ouray Formation. Additionally, excluding fluid storage that may occur in the Devonian Elbert and Cambrian Formations results in a lower



The draft permit contains a condition which states that EPA may with due cause, modify, revoke and reissue, or terminate the permit in accordance with Federal regulations, including if and when revisions or amendments to the Safe Drinking Water Act (SDWA) are made.

g. Injection Zone Hydrogeology

The injection zone is in the Leadville Limestone of Mississippian age and the Devonian age Ouray Formation. The Leadville Limestone occurs at a depth of 8,230 feet from surface and is 284 feet thick. The Ouray Formation is at 8,514 feet from surface and is not penetrated through the entire formation (TD is 8,583 feet; PBD is 8,535 feet). Lithology of the Leadville Limestone is limestone, often oolitic and fossiliferous, changing to dolomite in the lower half of the unit. The Ouray Formation is limestone and dolomite with occasional streaks of gray-green waxy shale.

Both formations are perforated in the interval of 8,480-8,534 feet from surface. Hydrogeologic parameters for this interval are:

Porosity = 8%

Permeability = 2.7 md

Fluid pressure = 2,500 psi

Fracture pressure = 4,330 psi

Bottom hole pressure = 3,220 psi at 3 BPM

Bottom Hole temperature = 180° F

Total Dissolved Solids (TDS) ranges from 3,000 - 100,000 ppm, depending on the location of the gas water interface ("Free water" is the higher TDS value).

h. Confining Zone Hydrogeology

The overlying Molas Formation has been described as the confining zone for the Woods #3 (MWD-1) well which is also in the McElmo Dome Field. Because of the consistency in geology across the McElmo Dome field, the Molas Formation shall be considered the confining zone for the entire Hovenweep well as well. The Molas Formation is a Pennsylvanian age redbed, consisting of interbedded red siltstone and sandstone, light colored limestone and varicolored shales. This formation was evaluated by electric logs to estimate its petrophysical properties. These logs included a Borehole Compensated Sonic Log, a Compensated Neutron Log, a Formation Density Log, a Dual Laterolog and microlaterolog-microlog. The interpretation of these logs showed the formation to be approximately 114 feet thick. The shales and siltstones of the Molas Formation have apparent log porosity but are impermeable. The limestone intervals are tight, with porosity less than two percent.

Other shale formations between the injection zone and the lowermost possible USDW include the Cutler Formation, the Moenkopi Formation and the Chinle Formation. These three units are considered redbeds and have low permeabilities. The Chinle Formation is 706' thick, the Moenkopi Formation is 49' thick and the Cutler Formation is 1,777' thick. Calculations of TDS concentrations using resistivity logs have shown the Chinle and Cutler Formations not to be USDW's, although they are water bearing and produce water elsewhere in the region.



b. Stratigraphy

The Colorado Plateau is characterized by thick sedimentary sequences and a tectonically stable environment since Precambrian time. The stratigraphic units, penetrated by the Hovenweep (HWD-1) well, are shown in the appendix to this Fact Sheet.

c. Hydrogeology

Hydrogeologic horizons have been identified (in the reports referenced or included in the Administrative Record) to be surficial deposits which are normally less than 20 feet thick except along valley bottoms. No water wells utilize these types of deposits in the area, (Romero, 1985). "Dakota Sandstone, Burro Canyon, and Salt Wash Member strata are known aquifers in other areas and probably have water yielding properties in Section 16. The Junction Creek and Entrada Sandstones are known aquifers and a well about three miles to the east in Section 13 probably taps one or both of these sandstones. Geologic units below the Entrada and above the Hermosa (Navajo, Wingate, Chinle) yield small quantities of water to wells in other areas, but nothing is known of their water yielding potential in the vicinity of the McElmo Dome Unit application", (Romero, 1985), [See appendix for depths to rock units penetrated by the Hovenweep wellbore].

The Leadville/Ouray formation water quality is quite variable. The TDS concentration ranges from 3,000 ppm to over 100,000 ppm depending where the water sample is taken. The lower TDS values are drawn from above the gas-water interface, where the water is in vapor form and drops out as condensation, with the change in pressure and temperature when the gas is produced. The higher TDS concentrations come from below the gas-water interface where "free water" is occurring. The injection zone, in the permit application, was shown to have a TDS concentration of 78,727 ppm. The injected fluid has a TDS concentration of 3,155 ppm, the porosity of the zone is 8% with a permeability of 2.7 millidarcy (md).

3. WELL CONSTRUCTION

The SWEPI Hovenweep (HWD-1) well was spudded November 21, 1978, and total depth (TD) was reached January 14, 1979. The well was initially drilled as a CO<sub>2</sub> exploratory well but the well was found to be uneconomical for CO<sub>2</sub> production. The well was originally perforated at 8289 - 8448 feet for testing productivity. On November 11, 1983, this interval was cement squeezed with 150 sacks of class H cement and production was abandoned. The well was re-perforated at 8580 - 8534 feet on November 21, 1983 and stimulated with 125 bbls of 15% hydrochloric acid. An injectivity test and pressure test to 1000 psi were performed on December 2, 1983. It was completed for injection purposes on December 6, 1983.

## ATTACHMENTS TO COMPLETION REPORT HWD-1

### I. Geologic Information

#### 1. Lithology and Stratigraphy

##### A. Description of Rock Units Penetrated

Name: Dakota  
Age: Cretaceous  
Depth: Outcrops at surface  
Thickness: 570'  
Lithology: Light gray sandstone and carbonaceous shale

Name: Morrison  
Age: Jurassic  
Depth: 570'  
Thickness: 190'  
Lithology: Light Gray to pink sandstone and green or red mudstone

Name: Bluff  
Age: Jurassic  
Depth: 760'  
Thickness: 265;  
Lithology: Gray to buff sandstone

Name: Summerville  
Age: Jurassic  
Depth: 1025'  
Thickness: 118'  
Lithology: Red, sand mudstone, red sandstone and minor chert

Name: Entrada  
Age: Jurassic  
Depth: 1143'  
Thickness: 105'  
Lithology: Light buff, reddish brown or salmon colored fine-grained sandstone

Name: Carmel  
Age: Jurassic  
Depth: 1248'  
Thickness: 17'  
Lithology: Reddish brown sandy siltstone and silty sandstone



Name: Navajo  
Age: Jurassic  
Depth: 1265'  
Thickness: 133'  
Lithology: Buff to pale orange cross-bedded sandstone

Name: Kayenta  
Age: Triassic  
Depth: 1398'  
Thickness: 42'  
Lithology: Reddish sandstone and interbeds of red or green mudstone

Name: Wingate  
Age: Triassic  
Depth: 1440'  
Thickness: 510'  
Lithology: Pale orange and brown, fine-grained sandstone

Name: Chinle  
Age: Triassic  
Depth: 1950'  
Thickness: 706'  
Lithology: Reddish brown siltstone and sandstone, reddish brown to variegated bentonitic mudstone, and minor gray conglomeratic sandstone

Name: Moenkopi  
Age: Triassic  
Depth: 2656'  
Thickness: 49'  
Lithology: Reddish brown laminated siltstone, sandy siltstone and minor very fine-grained sandstone

Name: Cutler  
Age: Permian  
Depth: 2705'  
Thickness: 1777'  
Lithology: Interbedded red, orange, and purple sandstones, siltstones and shales

Name: Honaker Trail  
Age: Pennsylvanian  
Depth: 4482'  
Thickness: 1028'  
Lithology: Interbedded gray sandstones, limestones and shales with scattered amounts of gray and orange chert.

Name: Paradox  
 Age: Pennsylvanian  
 Depth: 5510'  
 Thickness: 2460'  
 Lithology: Interbedded salt, anhydrite, dark colored dolomites and black shale

Name: Pinkerton Trail  
 Age: Pennsylvanian  
 Depth: 7970'  
 Thickness: 146'  
 Lithology: Light gray limestones and gray to gray-green shales, siltstones and sandstones

Name: Molas  
 Age: Pennsylvanian  
 Depth: 8116'  
 Thickness: 114'  
 Lithology: Interbedded red siltstones, sandstones, light colored limestones and varicolored shales

Name: Leadville  
 Age: Mississippian  
 Depth: 8230'  
 Thickness: 284'  
 Lithology: Limestone, often oolitic and fossiliferous changing to dolomite in the lower half

Name: Ouray  
 Age: Devonian  
 Depth: 8514'  
 Thickness: NP  
 Lithology: Limestone and dolomite with occasional streaks of gray-green waxy shale

#### B. Description of Injection Unit

Name: Leadville  
 Depth: 8230'  
 Thickness: 284'  
 Fluid Pressure: 2500 psi  
 Age: Mississippian  
 Porosity: 8%  
 Permeability: 2.7 md  
 Bottom hole temperature: 180°F  
 Lithology: Limestone and Dolomite  
 Bottom hole pressure: 3220 psi @ 3 BPM  
 Fracture pressure: 4330 psi





00549734

UNITED STATES  
OF THE INTERIOR  
BUREAU OF LAND MANAGEMENT

SUBMIT IN DUPLICATE\*

(See other In-  
structions on  
reverse side)

Form approved.  
Budget Bureau No. 1004-0137  
Expires August 31, 1985

WELL COMPLETION OR RECOMPLETION REPORT AND LOG \*

1a. TYPE OF WELL: OIL WELL ☐ GAS WELL ☐ DRY ☐ Other SWD

b. TYPE OF COMPLETION: NEW WELL ☒ WORK OVER ☐ DEEP EN ☐ PLUG BACK ☐ DIFF. CENVR. ☐ Other Converted to SWD

2. NAME OF OPERATOR Shell Western E&P, Inc. (See remarks on reverse)

3. ADDRESS OF OPERATOR  
P. O. Box 991, Houston, TX 77001

4. LOCATION OF WELL (Report location clearly and in accordance with any State requirements)

At surface 300' FSL & 515' FEL, Sec. 9

At top prod. interval reported below Same

At total depth Same

RECEIVED

JUL 11 1984

COLO. OIL & GAS CONS. COMM.

5. LEASE DESIGNATION AND SERIAL NO.

C-10103

6. IF INDIAN, ALLOTTEE OR TRIBE NAME

7. UNIT AGREEMENT NAME

McElmo Dome Unit

8. FARM OR LEASE NAME

McElmo Dome Unit 9-38-18

9. WELL NO.

HWD-1

10. FIELD AND POOL, OR WILDCAT

McElmo Dome

11. SEC. T. R. M. OR BLOCK AND SURVEY OR AREA

Sec. 9. T37N, R18W, NMPM

14. PERMIT NO. DATE ISSUED

NA

8/3/78

12. COUNTY OR PARISH

Montezuma

13. STATE

Colorado

15. DATE SPUDDED 16. DATE T.D. REACHED 17. DATE COMPL. (Ready to prod.)

11/21/78

1/14/79

12/6/83

18. ELEVATIONS (OF, RKB, RT, GR, ETC.)\*

6877' GR

19. ELEV. CASINGHEAD

--

20. TOTAL DEPTH, MD & TVD

8583

21. PLUG. BACK T.D., MD & TVD

8535

22. IF MULTIPLE COMPL. HOW MANY\*

--

23. INTERVALS DRILLED BY

--

ROTARY TOOLS

X

CABLE TOOLS

--

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)\*

8480-8534 (L. Leadville)

25. WAS DIRECTIONAL SURVEY MADE

No

26. TYPE ELECTRIC AND OTHER LOGS RUN

CBL/temp log/depth correlation log

27. WAS WELL CORED

No

28. CASING RECORD (Report all strings set in well)

CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PULLED
13 3/8"	48	50	17 1/2"	75sx C + 2% CaCl <sub>2</sub>	--
9 5/8"	36.32.3	2873	12 1/4"	600sx Lite + 200 sx B	--
7"	23.29	8020	8 3/4"	600sx Lite + 350 sx B	--

29. LINER RECORD

SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)	SIZE	DEPTH SET (MD)	PACKER SET (MD)
4 1/2"	7827	8581	150		3 1/2"	8172	8093

31. PERFORATION RECORD (Interval, size and number)

8480-8534 (4 JSPF/O degree phase, 13.5  
grans/shot)

32. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MATERIAL USED
<u>8480-8534</u>	<u>acidized w/113 bbls 15% HCL acid</u>
<u>8326-8448</u>	<u>squeezed w/150 sx Class H cmt</u>

33.\* PRODUCTION

DATE FIRST PRODUCTION PRODUCTION METHOD (Flowing, gas lift, pumping—size and type of pump) WELL STATUS (Producing or shut-in)

CONVERTED TO SALT WATER DISPOSAL WELL

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD	OIL—BBL.	GAS—MCF.	WATER—BBL.	GAS-OIL RATIO
FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE	OIL—BBL.	GAS—MCF.	WATER—BBL.	OIL GRAVITY-API (CORR.)	

34. DISPOSITION OF GAS (Sold, used for fuel, vented, etc.)

TEST WITNESSED BY

35. LIST OF ATTACHMENTS

Logs

36. I hereby certify that the foregoing and attached information is complete and correct as determined from all available records

SIGNED

A.J. Fore

TITLE Supvr. Reg/Permits

DATE 7/9/84

\*(See Instructions and Spaces for Additional Data on Reverse Side)